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OBSERVATIONS ON THE HYDROLOGY AND MARINE ORGANISMS OF THE TIDAL COLORADO RIVER AND ADJACENT WATERS, TEXAS, FEBRUARY–JUNE 1962

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ABSTRACT

Salinity and temperature measurements and collections of organisms at 2-week intervals began in February, 1962 and continued through June, 1962 at 10 stations in the tidal Colorado River of Texas and adjacent waters.

Surface salinity ranged from 1.0‰ (parts per thousand) to 31.2‰ and bottom salinity ranged from 10.6‰ to 31.2‰. Surface salinity fluctuated the most in the Colorado River, increasing with flood tide and decreasing with ebb tide while the least fluctuation occurred in East Matagorda Bay, reflecting the reduced influence of tides and high evaporation-precipitation ratio. Surface and bottom salinity differences were the greatest (28.5‰) in the river and the Gulf Intracoastal Waterway where mixing was slight, and the least (8.4‰) in the bays where mixing was the greatest.

Water temperatures (surface and bottom) paralleled the general warming trend of air temperature. Temperatures of bottom waters during February and early March were warmer than those of surface waters, but the situation reversed itself during the remainder of the study.

Eighteen species of invertebrates and 39 species of vertebrates were collected. Ctenophores, brown shrimp (*Penaeus aztecus*), and blue crabs (*Callinectes sapidus*) were the most abundant invertebrates while the Atlantic croaker (*Micropogon undulatus*), spot (*Leiostomus xanthurus*), and sand seatrout (*Cynoscion arenarius*) were the most abundant vertebrates. Nearly all of the abundant species displayed numerous peaks within the study area during May or June with a corresponding increase of size as the season advanced from February to June.

INTRODUCTION

Published information on the hydrology and biology of the Colorado River-Matagorda Bay area is limited and fragmentary. Galtsoff (1931) described the salinity regime and oyster producing areas in Matagorda Bay. Shenton (1957) studied the foraminifera and bottom sediments of Matagorda Bay, and Marland (1958) studied the ecology of the molluscan fauna. Day (1959a, 1959b, 1961a, and 1961b) listed 44 forms of invertebrates and 98 vertebrates that were collected in Matagorda Bay.

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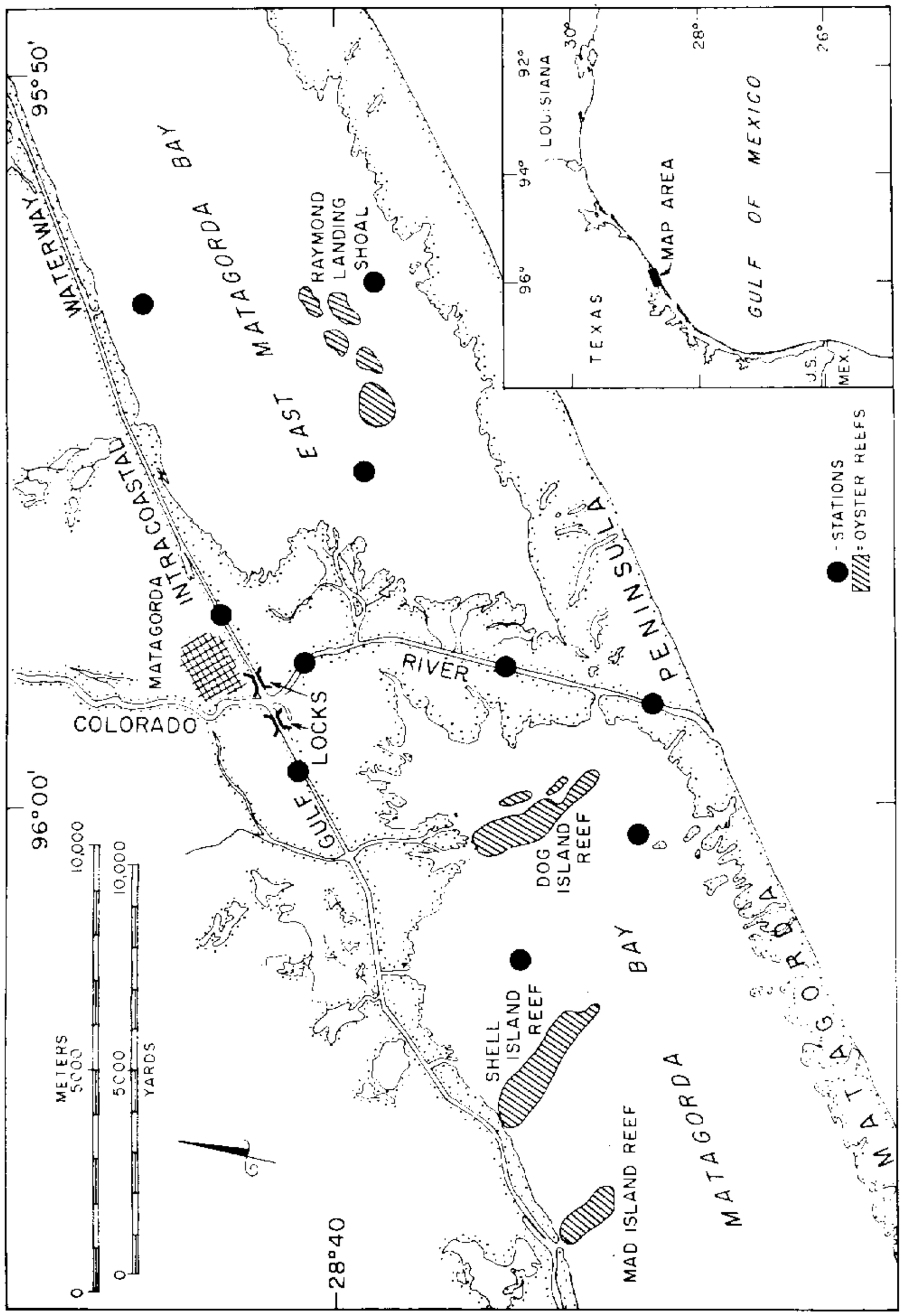

FIG. 1. The Colorado River Delta, Texas and adjacent waters with locations of 10 hydrographic and biological sampling stations.

In general, the literature on Matagorda Bay does not treat the eastern arm, tidal reaches of the Colorado River, Gulf Intracoastal Waterway, or East Matagorda Bay as extensively as it does the bay proper.

This description of the hydrology and the faunal components of these waters in late winter and spring is offered as a contribution toward a more comprehensive understanding of the environmental and biological characteristics of the Matagorda Bay area.

The Study Area

The Colorado River Delta, formed after 1924, bisects the original eastern arm of Matagorda Bay into two distinct bays (Fig. 1). These two bays are further subdivided superficially by several oyster reefs. Two of these reefs—Shell Island Reef in the eastern arm of Matagorda Bay, and Raymond Landing Shoal in East Matagorda Bay—approximate the western and eastern limits of the study area. The widths of the two bays are as great as 8 km and the distance between the two reefs is about 18 km.

Depths at mean low water are similar in the two bay areas. East Matagorda Bay has a relatively flat featureless bottom with depths at many points as great as 1.5 m at mean low water (m.l.w.); depths averaged about 1.1 m. East of Shell Island Reef, Matagorda Bay has a relatively level bottom with a maximum depth of about 2.1 m and an average of about 0.9 m.

The Gulf Intracoastal Waterway and the river channel have uniform depths of 3.7 m (m.l.w.) that are maintained by dredging. Surface width of the Waterway is about 45 m; width of the river ranges from 90 m along most of its length through the delta to about 115 m at the point of junction with the Waterway. Maintained bottom widths of the river and the Waterway are about 38 m.

The range of diurnal tides in the Matagorda Bay area varied from about 0.2 m to nearly 0.4 m in 1962 (U.S. Coast and Geodetic Survey Tide Tables, 1962). Continuous winds for several days, however, affect the predicted time and heights of the tides. Reid (1955) noticed this phenomenon during his investigations in the estuaries northeast of Galveston, Texas.

MATERIALS AND METHODS

Measurements of salinity and temperature and collection of organisms at 10 stations began at 2-week intervals in February, 1962 and continued through June, 1962. The stations were in four bodies of water that represented three basic habitat types: the tidal reaches of a river, a man-made waterway, and adjacent segments of two bays. Three stations were in the Colorado River, two in the Gulf Intracoastal Waterway, two in the eastern portion of Matagorda Bay (hereafter referred to as Matagorda Bay), and three in East Matagorda Bay. Total observations in each area are listed in Table 1.

Salinity and temperature were measured in surface and bottom waters. Surface temperatures

TABLE 1

Number of hydrographic observations and trawl hauls by habitat, February to June 1962

	Colorado River	Gulf Intracoastal Waterway	Matagorda Bay	East Matagorda Bay
	Number	Number	Number	Number
Salinity:				
Surface	32	20	18	26
Bottom	32	20	18	26
Temperature:				
Surface	32	20	17	24
Bottom	31	20	15	23
Trawls:	32	20	18	25

were obtained by reading a centigrade thermometer held in a bucket of freshly drawn water. Bottom temperatures were obtained similarly after the water was collected with a 400-cc Kemmerer water sampler. Salinities were determined in the laboratory by a modification of the Mohr-Knudson titration method described by Marvin, Zein-Eldin, May, and Lansford (1960). Tidal readings were taken at the staff gauge on the Colorado River locks at Matagorda.

Marine organisms were collected with a try-net. The net, with an opening of 3.0 m, was towed behind an outboard skiff for 10 minutes over a distance of about 450 m. The stretched mesh size of the wings of the net was about 3.5 cm and that of the bag or cod-end about 2.5 cm. Trawl doors measured approximately 29.2 by 66.0 by 2.5 cm.

Measurements of fish and invertebrates, other than shrimp and crabs, were of total length in millimeters. For fish, this measurement represents a straight line from the tip of the snout to the end of the tail with the caudal rays squeezed together. Carapace widths of crabs were measured and analyzed separately by sex. Penaeid shrimp were weighed to the nearest gram.

HYDROLOGY

Salinity

The data suggest that the salinity regime of the study area is complex, characterized by wide ranges and frequent fluctuations. Salinities of surface water samples ranged from 1.0‰ to 31.2‰ and those of bottom waters from 10.6‰ to 31.2‰ (Table 2). Fluctuations in salinities differed markedly between the four habitats studied (Fig. 2).

Much of the flow of the Colorado River enters directly into the Gulf of Mexico, however, small amounts enter the Gulf Intracoastal Waterway and eastern Matagorda Bay. Of these bodies of water, tidal influence is strongest in the Colorado River where fluctuations in surface salinities were the greatest, increasing with flood tide and decreasing with ebb tide. Salinities were lowest near the Gulf Intracoastal Waterway and highest near the mouth. Fluctuations in bottom salinities were not as great, and values were generally higher than in surface waters. Indications of seasonal increase or decrease in salinity values were not apparent in either surface or bottom waters.

During the study, the mean monthly discharge of the Colorado River at Bay City ranged from 341 to 1,183 cfs (cubic feet per second) (9.65 to 33.49 cu. m per second) and averaged 768 cfs (21.74 cu. m per second) (U.S. Geological Survey, 1962). This flow was considerably lower than the 14-year average of 2,541 cfs (71.95 cu. m per second), and fluctuations in discharge could not be correlated with salinity.

In the Gulf Intracoastal Waterway, salinities of surface and bottom waters fluctuated markedly with no apparent seasonal trend. Fluctuations were similar at the surface and bottom. Average bottom salinities ranged from 14.6‰ to 25.1‰ and were generally lower than any of those recorded in the other three habitats.

In the two bay areas, salinities generally increased during the study. Exceptions to this seasonal trend occurred in Matagorda Bay in early May and June when an intrusion of fresh water lowered average salinities. In East Matagorda Bay, however, fluctuations in salinities were less than in any other area. This body of water was not directly influenced by any appreciable source of fresh or salt water. Salinities gradually increased with little variation, a feature unlike the other three habitats. Such a trend may be ascribed, in part, to reduced influ-

TABLE 2

Ranges of salinity and temperatures by month and habitat in the Colorado River Delta area, February–June 1962

Water body	February ‰	February °C	March ‰	March °C	April ‰	April °C	May ‰	May °C	June ‰	June °C
Colorado River										
Surface	2.5–30.6	13–19	2.3–10.3	13–19	3.7–25.0	18–23	1.3–29.6	26–28	1.0–13.3	30–31
Bottom	15.8–31.0	14–20	17.5–26.3	14–17	20.8–28.3	18–22	21.0–29.9	25–28	12.8–28.2	28–30
Gulf Intracoastal Waterway										
Surface	14.7–15.2	19–20	9.2–21.2	14–21	15.7–24.7	19–23	8.9–22.8	24–28	7.8–12.3	29–30
Bottom	15.7–16.9	20	17.5–22.0	13–19	19.1–26.4	18–22	11.7–23.3	23–28	10.6–22.6	27–30
Matagorda Bay										
Surface	*	*	17.4–26.3	12–21	22.9–27.9	18–24	18.8–31.2	26–28	16.3–27.8	30
Bottom	*	*	18.5–26.8	12–20	26.3–28.0	18–24	20.4–31.2	26–28	17.3–27.9	29–30
East Matagorda Bay										
Surface	17.5	21	18.9–22.5	13–19	21.5–26.0	19–23	23.3–27.9	24–26	25.7–27.9	27–29
Bottom	17.9	22	21.1–22.6	14–16	22.5–26.0	19–23	23.5–28.1	24–26	26.2–28.1	27–29

* No data.

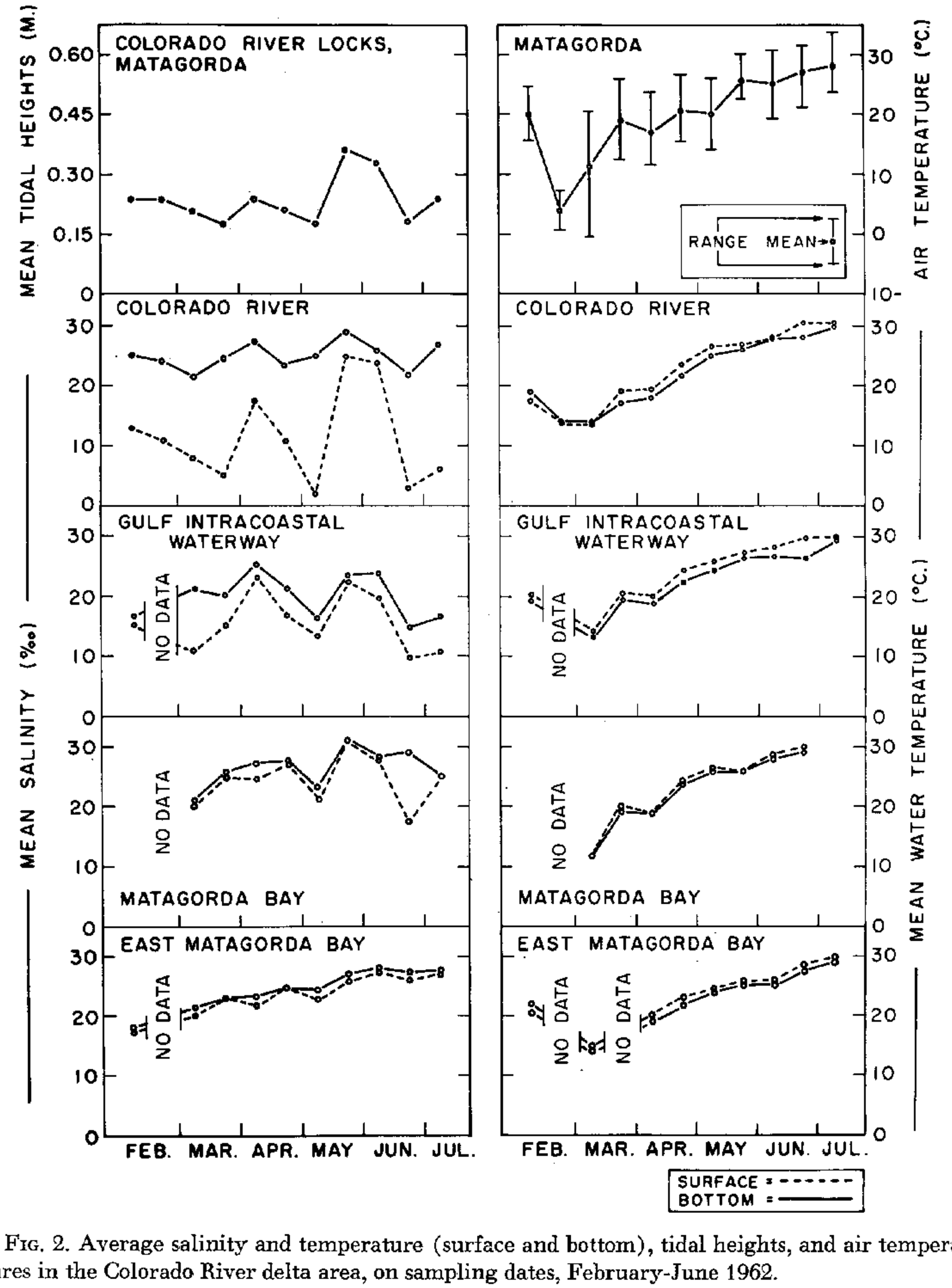

FIG. 2. Average salinity and temperature (surface and bottom), tidal heights, and air temperatures in the Colorado River delta area, on sampling dates, February-June 1962.

ences of tides, low rainfall (according to the U.S. Weather Bureau, about 55 mm, or 2.2 inches, below the normal of 371 mm or 14.1 inches for the February-June period) and increased evaporation (Collier and Hedgpeth, 1950).

Differences between surface and bottom salinities measured simultaneously were greater in the channel habitats than in the two bays. At certain stations in the Colorado River and Gulf Intracoastal Waterway, differences were as great as

28.5‰, whereas in the two bays they were no greater than 8.4‰. This condition may be attributed to the fact that the broad and shallow bays are more affected by wind-driven waves that mix surface and bottom waters than are the narrow and deeper river and Waterway channels.

Temperature

Unlike salinities, surface and bottom water temperatures followed similar patterns throughout the study area and were related to air temperature (Fig. 2). At no time did surface water temperature deviate more than 3°C from that of bottom water. The 3°C difference was noted in simultaneous surface and bottom readings at stations in the Colorado River and the Intracoastal Waterway. Surface temperatures in February and March were generally cooler than bottom temperatures, but these conditions were reversed when air temperatures increased and stabilized during the remainder of the study.

Air temperature (converted to °C from U.S. Weather Bureau data for Matagorda, Texas) on sampling dates dropped from an initial high of 24.5°C in February to a low of 0.5°C in early March (Fig. 2). Air temperature then gradually increased until a high of 33.5°C was recorded in June. This trend was paralleled by surface and bottom temperatures.

FAUNA

Eighteen species of invertebrates and 39 species of vertebrates were collected in a series of 95 try-net samples. One invertebrate, a ctenophore, was taken in such large numbers that enumeration was impossible. Of the remaining forms, six species of invertebrates and eight species of vertebrates were abundant enough to be considered as "common." These accounted for 13,748 individuals or 97.1% of the total catch of 14,155 individuals (Table 3).

Analysis of size data of the common forms indicated that few small or large individuals, notably fish under 15 mm or over 150 mm, were taken in the try-net. The paucity of small individuals reflects escapement through the large mesh net, whereas large individuals may have either escaped the net or moved to waters of generally higher salinity as they approached maturity. This latter phenomenon with respect to approach of maturity was described by Gunter (1945, 1950) for fish and invertebrates inhabiting coastal waters of Texas.

Invertebrates

The six common invertebrate forms listed in Table 3 represent about 98.5% of all invertebrates, exclusive of ctenophores. Of these, the brown shrimp (*Penaeus aztecus*), the blue crab (*Callinectes sapidus*), and the white shrimp (*P. setiferus*) constitute much of the volume and value of the Texas commercial fishery harvest. All of the common invertebrates listed have been reported in the diets of such fish as the spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogon undulatus*), and the sand seatrout (*Cynoscion arenarius*).

With the exception of the ctenophore, the invertebrate taken most frequently

TABLE 3

Grouping of 17 invertebrate and 39 vertebrate forms taken by trawling during February–June 1962

	Total catch
INVERTEBRATES (exclusive of ctenophores)	
Common forms:	
Penaeus aztecus	3,606
Callinectes sapidus	611
Palaemonetes spp.	319
Penaeus setiferus	299
Callinectes similis	277
Sergestidae, unid.	198
Uncommon forms:	
Lolliguncula brevis	47
Portunus sayi	9
Euphausiidae, unid.	6
Squilla empusa	5
Macrobranchium ohione	5
Penaeus duorarum	2
Trachypenaeus constrictus	1
Xiphopenaeus krøyeri	1
Neopanope texana	1
Ovalipes ocellatus	1
Maiidae, unid.	1
VERTEBRATES	
Common forms:	
Micropogon undulatus	5,545
Leiostomus xanthurus	1,602
Cynoscion arenarius	508
Lagodon rhomboides	233
Brevoortia patronus	169
Anchoa mitchilli	163
Arius felis	113
Citharichthys spilopterus	105
Uncommon forms:	
Symphurus plagiusa	51
Porichthys porosissimus	51
Paralichthys lethostigma	49
Stellifer lanceolatus	30
Polydactylus octonemus	21
Urophycis floridanus	19
Bairdiella chrysura	19
Sphoeroides parvus	18
Trinectes maculatus	9
Menticirrhus americanus	8
Achirus lineatus	7
Prionotus tribulus	6
Dasyatis sabina	5
Pogonias cromis	4
Archosargus probatocephalus	4
Chaetodipterus faber	4
Gobionellus hastatus	3

	Total catch
Gobiesox strumosus	3
Synodus foetens	2
Cynoscion nebulosus	2
Gobiosoma bosci	2
Mugil cephalus	2
Bagre marinus	1
Orthopristis chrysopterus	1
Trichiurus lepturus	1
Gobioides broussonneti	1
Microgobius spp.	1
Astroscopus y-graecum	1
Hypsoblennius ionthas	1
Ancylopsetta quadrocellata	1
Monacanthus hispidus	1
Total	14,155

was *Penaeus aztecus* (Tables 3 and 4). This is the most valuable single species taken by the commercial fishery of Texas. Overall, the brown shrimp ranked third in abundance behind ctenophores and *Micropogon undulatus*. *P. aztecus* was first collected in April and reached a numerical peak in late May which was followed by a decline in June. This species displayed a gradual weight increase between April and June; the weight of specimens taken in April ranged from 0.6 to 2.2 g and averaged 0.8 g, while the weight of those taken in June ranged from 0.6 to 9.7 g, averaging 1.8 g. Specimens as heavy as 18.4 g were taken in May, but the greatest abundance of individuals under 2.0 g held the average to 1.4 g.

The third ranking invertebrate was *Callinectes sapidus* which also enters the sport and commercial fishery of Texas. The blue crab was collected throughout the study area with the greatest catches made in early April (Table 4). The size (width) of 265 males increased, with those taken in February ranging from 11 to 61 mm and averaging 41.6 mm, while those taken in June ranged from 19 to 228 mm, averaging 134.7 mm. The 346 females collected displayed a similar size increase. March specimens ranged from 13 to 67 mm and averaged 40.0 mm, while those taken in June ranged from 21 to 197 mm, averaging 105.6 mm.

Penaeus setiferus was collected sporadically throughout the study with the numerical peak appearing in late June (Table 4). *P. setiferus* were, however, scarce in the two bays with only 10 specimens or about 3% of the total catch being taken. Specimens taken between February and May ranged in weight from 3.4 to 51 g and averaged 5.8 g, while those taken in June ranged from 0.2 to 6.6 g, averaging 0.7 g.

Callinectes similis was collected in May and June with the numerical peak appearing in late May (Table 4). This crab was taken throughout the study area but appeared to be least abundant in East Matagorda Bay. The width of 143 males ranged from 7 to 46 mm, averaging 24.1 mm, while that of 134 females ranged from 5 to 61 mm and averaged 20.9 mm.

TABLE 4

Number of specimens per try—net sample by date and habitat of selected species of invertebrates and vertebrates

Species	Area*	February 1	February 2	March 1	March 2	April 1	April 2	May 1	May 2	May 3	June 1	June 2	Cumulative total
Penaeus	I	0	0	0	0	0	1	3	28	109	79	78	298
aztecus	II	0	..	0	0	0	4	29	31	242	115	120	541
	III	..	..	0	0	0	1	3	28	95	15	25	167
	IV	..	..	0	0	1	26	72	51	159	61	67	437
Total		0	0	0	0	1	32	107	138	605	270	290	
Callinectes	I	1	0	4	0	17	13	25	5	1	1	4	71
sapidus	II	2	..	1	15	7	15	6	6	6	1	0	59
	III	..	..	0	1	10	9	8	15	10	6	9	68
	IV	..	..	6	23	15	6	7	7	4	2	2	72
Total		3	0	11	39	49	43	46	33	21	10	15	
Penaeus	I	1	0	1	0	5	1	2	3	1	0	43	57
setiferus	II	0	..	0	1	0	4	0	0	0	0	61	66
	III	..	..	0	0	0	0	1	1	0	0	0	2
	IV	..	..	0	0	0	0	0	0	0	0	2	2
Total		1	0	1	1	5	5	3	4	1	0	106	
Callinectes	I	0	0	0	0	0	0	13	7	7	2	5	34
similis ..	II	0	..	0	0	0	0	0	0	32	12	4	48
	III	..	..	0	0	0	0	4	0	30	2	1	37
	IV	..	..	0	0	0	0	0	1	3	1	1	6
Total		0	0	0	0	0	0	17	8	72	17	11	
Micropogon	I	9	10	13	7	64	78	29	12	17	8	9	256
undulatus	II	7	..	95	139	20	179	43	41	38	11	13	586
	III	..	..	17	2	94	127	95	54	53	28	9	479
	IV	..	..	40	388	79	121	225	112	89	61	39	1,154
Total		16	10	165	536	257	505	392	219	197	108	70	
Leiostomus	I	1	0	0	1	5	14	1	2	3	2	9	38
xanthurus	II	0	..	8	6	0	1	3	36	2	1	0	57
	III	..	..	6	24	14	0	5	5	0	11	14	79
	IV	..	..	33	2	33	88	103	57	30	25	43	414
Total		1	0	47	33	52	103	112	100	35	39	66	
Cynoscion	I	0	0	0	0	1	0	17	14	46	6	31	115
arenarius	II	0	..	0	0	0	1	2	6	12	5	10	36
	III	..	..	0	0	1	0	1	18	2	5	2	29
	IV	..	..	0	0	0	0	1	2	2	4	8	17
Total		0	0	0	0	2	1	21	40	62	20	51	

* Area I = Colorado River
II = Gulf Intracoastal Waterway
III = Matagorda Bay
IV = East Matagorda Bay
.. = No data

Vertebrates

Of the 39 vertebrate species taken in the try-net, 8 are considered as "common" and represent about 96.3 of the vertebrate catch (Table 3). Of these *Micropogon*

undulatus, *Leiostomus xanthurus* and *Cynoscion arenarius* are important to the sport and commercial fishery of Texas.

Micropogon undulatus was the most abundant species in the study area, accounting for about 39.2% of the entire try-net catch. The Atlantic croaker was taken from all habitats and catches were greatest in March and April (Table 4). Sizes increased gradually as the study progressed; specimens taken in February ranged from 14 to 137 mm and averaged 30.4 mm, while those taken in June ranged from 35 to 162 mm averaging 60.7 mm.

The second most abundant fish was *Leiostomus xanthurus* which was collected throughout the study period with the greatest catches made in early May (Table 4). About 77% of the total catch of the spot was taken from East Matagorda Bay. The size of this species increased gradually as the study progressed; specimens taken in February ranged from 13 to 42 mm and averaged 28.5 mm, while those taken in June ranged from 34 to 106 mm, averaging 51.0 mm.

Cynoscion arenarius was first caught in April and occurred throughout the study area until the end of June (Table 4). Sand seatrout were most abundant in late May and the greatest catches, made in the Colorado River, represented about 67% of the total catch for this species. The largest specimens, ranging from 41 to 192 mm and averaging 126.6 mm were taken in April, but smaller fish ranging from 22 to 73 mm and averaging 34.7 mm were collected during May and June.

DISCUSSION AND SUMMARY

The Colorado River-Matagorda Bay area has physical and biological features not unlike other estuarine areas on the upper Texas coast. Salinity ranges recorded during the study are similar to those recorded in 1962 for Galveston Bay by Stevens (1963), for San Antonio Bay by Childress (1963) and for Aransas Bay by Schultz (1963). Generally salinity ranged from less than 10‰ near sources of fresh-water discharge and often surpassed 30‰ near tidal passes.

Common invertebrates and vertebrates in the study area are representative of those found in other estuaries on the upper Texas coast. During 1962, personnel of the Texas Parks and Wildlife Department (formerly Texas Game and Fish Commission) found that commercial shrimp (*Penaeus spp.*), blue crabs (*Callinectes sapidus*), Atlantic croaker (*Micropogon undulatus*), spot (*Leiostomus xanthurus*), and sand seatrout (*Cynoscion arenarius*) were major faunal components of Galveston, San Antonio and Aransas Bays. The pinfish (*Lagodon rhomboides*), spotted seatrout (*Cynoscion nebulosus*), largescale menhaden (*Brevoortia patronus*), and bay anchovy (*Anchoa mitchilli*) have also been listed as major species within these bays. The relative numbers of these species vary during different seasons and years.

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